DIAGNOSTICS OF DRUM TYPE WOOD SHREDDER MACHINES
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Abstract: *This paper investigates diagnostic methods and proposes modern service technologies for wood-processing equipment. The aim of this study is to ensure systematic, research-based wood-processing services and continuous, no-failure operation of facilities. We describe the working principle of a particular industrial, drum-type wood shredder and discuss the problems that occurred during operation, including potential excess engine load or construction imperfections. Cutting regime calculations are provided, along with a description of actual improvements and a comparison of cutting regimes before and after improvements.*

The intended result of this research is a monitoring unit which, with help of a few modifications, can be used on any drum-type wood processing equipment.

Key words: List 4-5 keywords. (wood-processing facilities, drum-type wood shredder).

1. INTRODUCTION

This paper is based on the dissertation and research conducted during its preparation. It is the first paper on the subject, describing the problem of the dissertation, the attainable target and a reflection on the research process at the present stage.

Given the current complex economic situation, employers are obliged to optimize their manufacturing processes and reduce the prime cost of an item, in a bid to survive and remain profitable. One means of saving is in manufacturing facility maintenance and repair.

It is possible to reduce expenditure on spare parts and avoid sudden stoppages by modelling a modern, thought-out, research and diagnostics based manufacturing facility service. A diagnostics model of the junction condition can be developed by performing a series of cyclic measurements and analyzing the results. In this way, the precise moment can be identified when expenditure on complementary parts resources is timely but not destructive.

The present research has been conducted in cooperation with Latvijas Finieris, Ltd, which is the leading secondary wood processing company in Latvia and has a very large number of manufacturing facilities at its disposal.

All of these require constant maintenance and repair, which usually results in major financial outlays. Added to this, sudden stoppages of manufacturing facilities for unscheduled repairs generate significant losses.

The focus of the current research is investigation and analysis of a waste wood shredder machine. At the present research stage, the setup has been carefully studied, its working principle and analysis have been conducted. The main problems and their probable causes have been identified. The work accomplished so far provides a basis for further study, for choosing measuring instruments and the appropriate methodology, as well as for developing a common service system.

2. FIELD OF APPLICATION

The object of the study is a drum-type wood shredding machine designed to process large amounts of waste wood into woodchips. We expect that results will be unified and applicable to any kind of drum-type wood shredder diagnostic system and service technology elaboration.

3. PROBLEM STATEMENTS

At this moment we have defined several problems related to setup of the operation process.
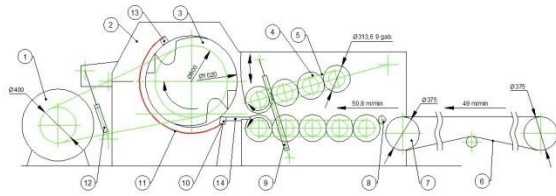

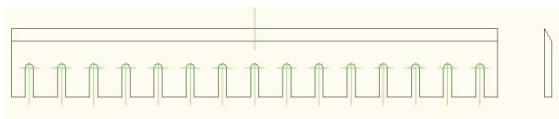Fig. 1. Shredder setup RAUTE TR 1020 – 1300 V kinematic scheme

Fig. 2. Blade sketch

Mostly these are connected with high dynamic loads, which occur in junctions during shredder machine operation.

The following problems in particular have been identified: (fig. 1., 10) corpus squirm; posterior counter knife deformation (fig. 1., 13); stowage of forward lead-in plate (fig. 1., 14) fixation screws and working blade wear (fig. 2).

Mainly, the impact initiated by the blade at the moment when the wood chip is chopped from the whole chipping mass is such that the load is delivered to the first supporting blade. The load is large enough to squirm the counter knife casing, see fig. 3.
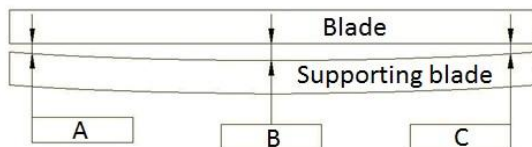

Fig. 3. Deformation of supporting blade.

When regulating the machine, a gap of 0.4-0.7 mm must be set between the blade and the supporting blade. After the said supporting blade casing deformation, it becomes impossible to restore the necessary gap. In particular, if the gap is set in the middle, the edges of blade go into the rotating blades operation zone; but if the regulation is performed at the edges, the middle gap becomes too large for the supposed standard. Engaging the squirmed supporting blade in the cutting process leads to increased loads in the working area and the wood chip quality decreases.

A load increase is induced not only by the blade-supporting blade gap, but also by normal blade wear which is inevitable. At this moment it is a common practice to use re-sharpened blades after a two-week working cycle. This service model is accepted and implemented without any theoretical background, there are no experimental results to affirm or refute the necessity of the described service cycle model.

Increasing cyclic loads in the shredder working area also increases load on the main engine. As a result there have been a number of cases of main engine overload and even fires.

4. RESEARCH COURSE

4.1. Data output

A summary of the working process describing parameters was required in order to undertake any kind of analysis and calculations. Some of these parameters have been partially changed in order to find precise values, and direct measurements have been performed. The main parameters and discrepancies between factory data and real setup working parameters can be seen in Table 1.

Parameter	Factory data	Actual data
Rotor diameter (mm)	1020	1020
Feed roll diameter (mm)	313.6	313.6
Rotor revolutions (rpm)	493	556
Supply speed (m/min)	50	44
Number of blades	2	3
Input hatch dimensions (mm)	1310x375	1310x375

Main engine power (kW)	200	200
Main engine revolutions (rpm)	1000	1000

Table 1. Shredder machine main parameters

4.2. Cutting process characteristic calculations

Further calculations that characterize the cutting process describe parameters and their real value compared with those announced by the manufacturer.

The difference is expressed in percentage form relating to the initial value, in order to evaluate the significance of discrepancies.

- Cutting speed

Cutting speed depends on the rotor diameter and revolution count. The rotor diameter remains constant while revolution count was altered therefore, cutting speed v is:

$$v = \frac{\pi \cdot D \cdot n}{100} \qquad (1)$$

where:

D – rotor diameter

n – rotor revolution count per minute

$$v_{original} = \frac{\pi \cdot 1020 \cdot 493}{1000} = 1580 m/min$$

$$v_{real} = \frac{\pi \cdot 1020 \cdot 556}{1000} = 1782 m/min$$

We can easily see that increasing the rotor revolution count leads to a cutting speed increase of approx. 12%.

- Supply speed on the teeth

Supply speed on the teeth depends on supply speed in one minute, rotor revolutions and the number of teeth in the rotor.

$$S_z = \frac{S_m}{n \cdot z} \qquad (2)$$

where:

Sm – supply speed in one minute

z – number of teeth

$$S_{z\ original} = \frac{50}{493 \cdot 2} = 0,051 m/z \rightarrow 51 mm/z$$

$$S_{z\ real} = \frac{44}{556 \cdot 3} = 0,026 m/z \rightarrow 26 mm/z$$

By setting more teeth in rotor, the revolution count has increased by 13%, supply speed has reduced by 12% and feed on the individual teeth has reduced by 51%. Accordingly, mean length of manufactured wood chip has reduced. At the same time, the aforementioned alterations have reduced the overall load on the shredder.

4.3. Shredder vibration forecast

The main cause of vibration in the working process is the floating/variable load, which occurs because of the cyclic entrance of blades into the working area.

The oscillation frequency is constant and can be easily obtained by equation 3. The variable value is the oscillation amplitude, depending on the amount of in-coming shredding material at a precise moment and condition of blades. The amount of supplied material is the time variable and hardly prognosable value because the amount depends on working modes of other related setups. It is not necessary to estimate described oscillations individually. But knife wear provokes regular amplitude raise, which include also oscillations caused by the amount of crumble mass alterations.

$$F = \frac{z \cdot n}{60} \rightarrow \frac{3 \cdot 556}{60} = 27.8 Hz \qquad (3)$$

where:

z – number of rotor teeth

n – rotor revolution count

As seen from the calculations, the basic oscillation/ vibration frequency is 27.8 Hz. This specific amplitude will be the main factor by which to draw conclusions about the condition of the blade and supporting blade.

5. METHOD USED, STATUS AND RESULTS

Currently measurements are being taken at regular intervals to reflect changes in the blade and supporting blade interaction during working process. This is achieved by measuring the gap between the blade and supporting blade at three points, once a day (figure 4, points A, B, C). These readings show both the progress of supporting blade deflection and total wear on the blade and supporting blade. As the in-situ experimental process is currently in the initial stage, the amount of gathered data is insufficient to give a statistically reliable description of wear progress or to develop a mathematical model that describes this process.

Up-to-date results relate to shredding machine working principle research and analysis, defining actual working characteristics and calculations. At this point, the main constructive improvements for the shredding machine have been defined, mentioning that further study can not take place without these improvements. The most problematic and important junction points have been defined, which require new service technology consisting of regular junction condition follow-up and a diagnostic-based maintenance system.

6. FURTHER RESEARCH

The next stage is to summarize blade and supporting blade interaction measurement data and place sensors under the supporting blade (figure 4). By setting up load sensors, it will be possible to follow-up and analyze over time the effect of increasing loads on the supporting blade.
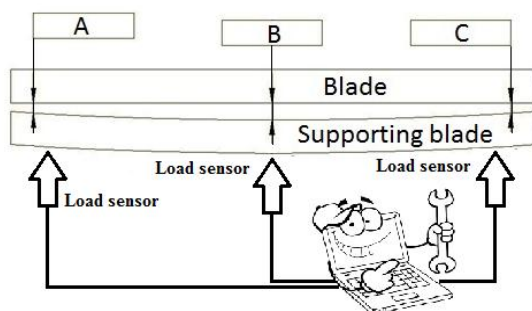

Figure 4. Measurement scheme

Following this, we shall define the relationship between the blade and supporting blade reciprocal wear condition and load sensor data, which in future will make it possible to perform indirect blade-supporting blade monitoring, based on load sensor measurement data. As a result of research, it is planned to develop a programme that will automatically signal when there is a need for facility maintenance or terminate operation of the facility, if necessary.

11. REFERENCES

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